

# **Mission Operations Working Group June 13-15, 2017**



## CloudSat Status

13 June 2017

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# Recent Overpass

(CA gets some much needed rain!)





### **Mission Status**



### CloudSat celebrated 11 years in Orbit on 28 April!

### **Daylight Only Operations**

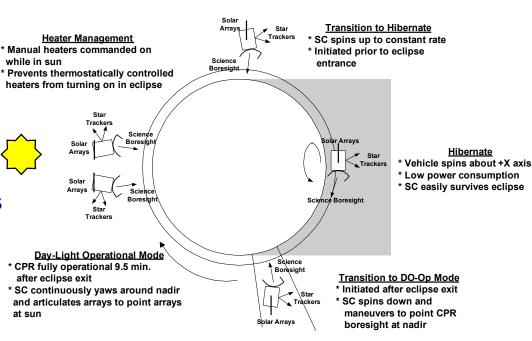
- Due to power restrictions
- Maneuvers in daylight also

#### S/C Health is Excellent

Life expectancy beyond FY '19.

### S/C Health/Redundancy Status

- CPR is fully redundant
- April 2011 Battery Anomaly
  - June 2011 Left A-Train
  - Daylight Only Operations
  - May 2012 Rejoined A-Train
- May 2011 Receiver 1 Probable Loss
  - Locked up at an off-nominal frequency
  - May be recoverable
  - Recovery efforts to date have been unsuccessful



### **Proactive Battery Management**

- Battery Health Checks
- Manual Mode /KI Charging (MMKI)
- Steady State / Ki Charging (SASSI)
  - SASSI discontinued June 2017



# Accomplishments

(Since the last MOWG)



### Senior Review Proposal for FY '18-'21

Headquarters Briefing / Response to Questions: 10 May 2017

### **Contingency On Orbit Handbook Revision**

- Rev H released in December 2016
- Walk Through & Contingency Training @ RSC in January 2017

#### **Command Block Modifications**

- T21 Blk 11 Updates for SASSI Testing: Nov '16 Jan '17
- T21 Blk 4d2 (DO-Op2) Updates for SASSI & MMKI: Feb '17 present
- T21 Blks 4 & 6 (DO-OP & PREP) CPR On & CPR Main Htr On: 19 Apr '17

### **Star Catalog Rotations (2)**

- December 2016
- June 2017

### **Solar Eclipses (1)**

- 26 February 2017
  - Commanded to STBY/PREP\*4
  - 9 Orbits of CPR Science Data Lost



# Accomplishments

(Since the last MOWG)

### Battery Manual / KI (MMKI) Charge Mode Implementation

MMKI with KI Boost Characterization: Mar '17 - present

### Steady State / KI (SASSI) Charge Mode Implementation

- Characterized SASSI Implementation (w/VT 5.0): Jul '16 Feb '17
- SASSI with KI Boost Characterization: Feb '17 present
- SASSI Implementation Discontinued: Jun '17

### **Spare Common Pressure Vessel (CPV) Operations**

Recharge Operations Discontinued

### **Weekly Battery Health Checks Continue**

- Suspended from 30 May 1 Aug '16 (due to seasonal loads)
- One orbit characterization per week (vs 3): 22 Aug '16 present

### **Magenetometer Model Update** (T53, 54 & 55)

- Development & Validation: Jan Mar '17
- Implementation: 25 Apr '17



## Formation Flying



### Fly within the Constellation Control Box

No excursion since the last MOWG in September 2016

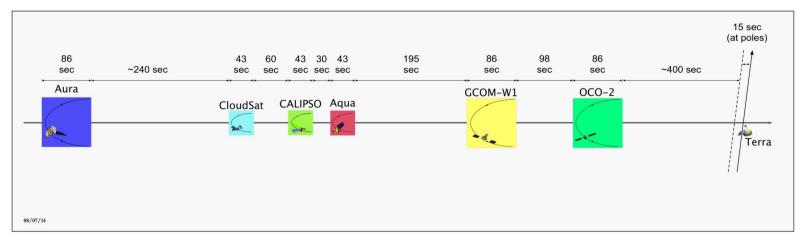
### **Formation Flying Strategy**

- Aim for 4km ground track overlap with CALIPSO 90% of the time
- Use Orbit Raises and Orbit Lowers as necessary
- No excursion since the last MOWG in September 2016

### 8 Maneuvers required since the last MOWG

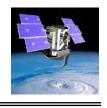
- 3 Orbit Raises / 3 Orbit Lowers
- 2 Inclination Decrease Maneuvers (2017 IAM Campaign)

### No dedicated maneuvers required for COLA / Risk Mitigation

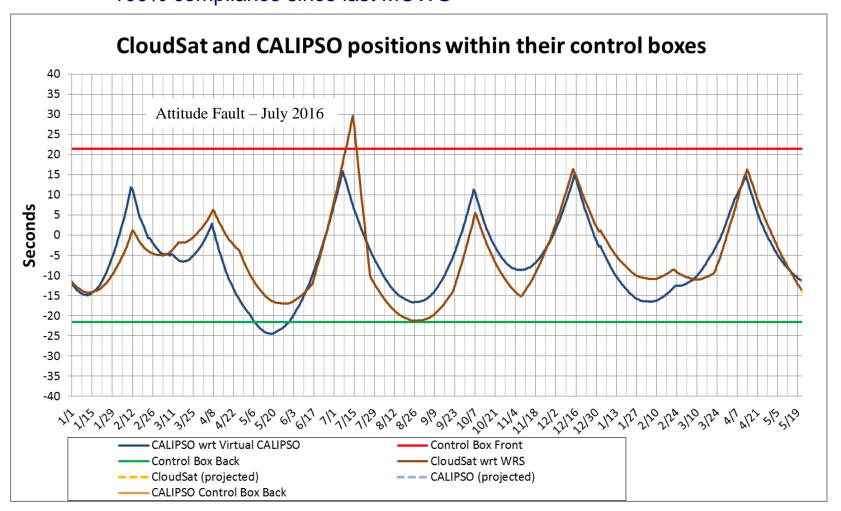




### Recent Performance



- Fly in Constellation Control Box
  - 100% compliance since last MOWG



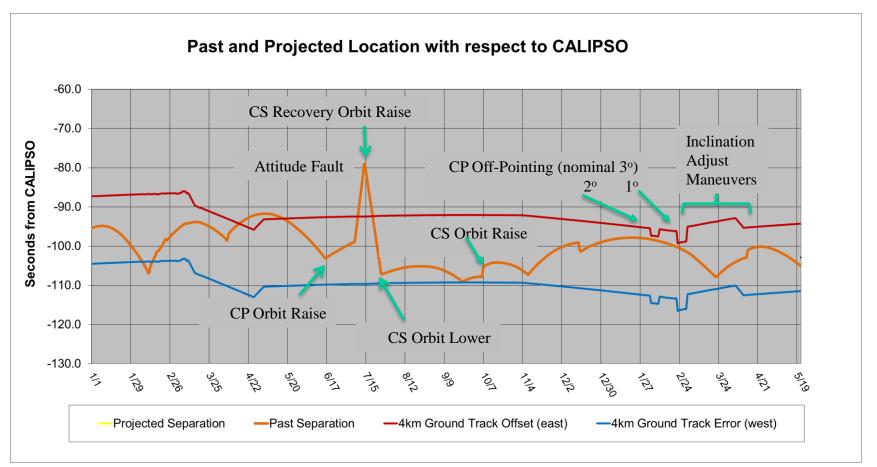


### Recent Performance



- Aim for 4km ground track overlap with CALIPSO 90% of the time

  100% according a last MOWC.
  - 100% compliance since last MOWG





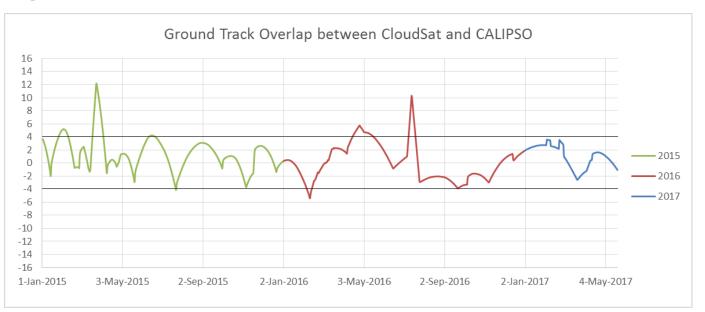
### **Overall Status**



# During 2016, maintained 4km overlap at the equator approximately 87% of the time

- Failed burn, inclination adjust campaign, changing solar activity resulted in loss of ground track overlap
- Ground track overlap improves away from the equator

# Since the start of 2017, CloudSat has maintained 4km overlap at the equator 100% of the time





# 2017 Inclination Adjust Maneuvers

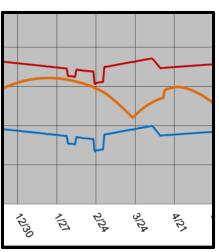


### Inclination Adjust Maneuver #1: 22 February 2017

- Desired delta-V: -2.75 m/sec
- Achieved delta-V: -2.768 m /sec
- Inclination change: -0.021137 deg
- SMA change = 1.85 m
- Percent error = 0.66% (over performance)

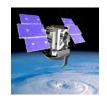
### • Inclination Adjust Maneuver #2: 11 April 2017

- Desired delta-V: -2.06 m/sec
- Achieved delta-V: -2.0599 m/sec
- Inclination change: -0.015876 deg
- SMA change: 1.684 m
- % error: -0.005% (under-performance)





# **CLOUDSAT** COLA/RMM Summary (since last MOWG)



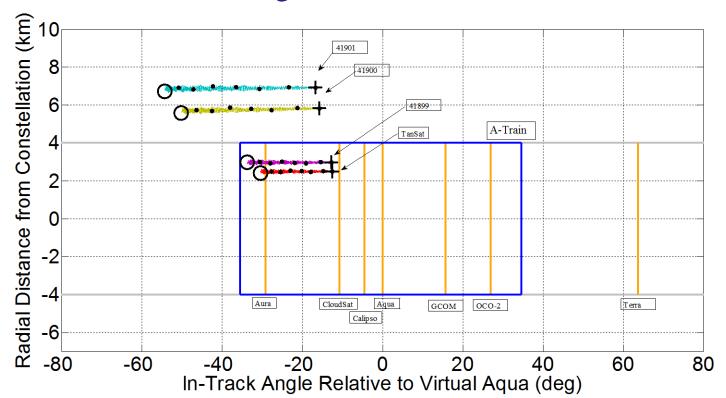
TCA Date / Time	Object Number	Object ID	First Identified On (Report Generation Time)		Highest Level of Action Taken
11/16/2016 21:28	35933	BEESAT	11/10/2016 2:36	2.04E-03	T3 - Conducted preliminary burn planning
4/25/2017 02:55	32166	FENGYUN 1C DEB	04/21/2017 7:22	2.25E-05	No action taken
5/4/2017 15:19	41898	TANSAT	04/27/2017 23:33	0	No action taken
5/24/2017 06:23	32233	FENGYUN 1C DEB	05/18/2017 23:32	4.83E-05	T1/T2 - Requested / received additional CARA Information



# TanSat Crossing



- On 21 December 2016, the Chinese launched the TanSat satellite into the vicinity of the A-Train (near CloudSat's in-track position, but 2km above)
- TanSat has been drifting above the A-Train ever since

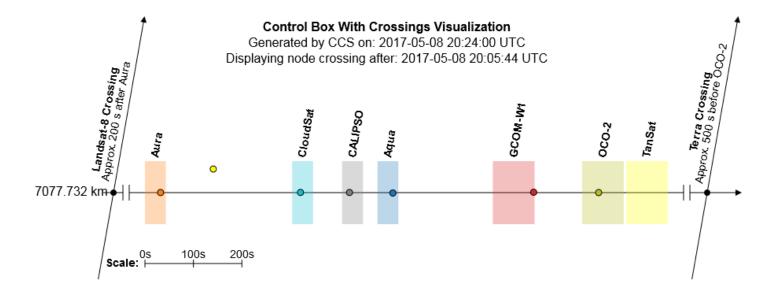




# TanSat Crossing



- On 4 May 2017, TanSat came within about 4.5km of CloudSat
  - Pc remained at zero
  - While this was not a particularly close conjunction, it is the closest TanSat has been to an A-Train satellite thus far
- Next projected crossing is in August 2017
- We continue to monitor TanSat with both the Air Force and NASA





### **Anomalies**

(Since the last MOWG)



#### Reaction Wheel #1 "Stick-tion" Event – 2 June 2017

- Reaction Wheel #1 began showing signs of "stick-tion" on Friday 2 June 2017
  - ✓ Events were evident when wheel speed rolled through zero crossing
  - ✓ Attitude errors tripped yellow limits, but remained far from red limits
- Friction became worse on Saturday 3 June 2017, so the spacecraft was commanded to Sun-Point-Spin (SPS)
  - ✓ This is a stable and power safe mode, in which to remain while recovery efforts are under way
  - ✓ The Cloud Profiling Radar (CPR) and reaction wheels are off
- All other flight systems are nominal, however science observations are not possible in SPS
- Neither the A-Train Exit Criteria nor any fault protection limits were triggered
- Experts advise that running wheel #1 up to 3000-5000 RPMs for several hours is the recommended coarse of action for resolution
  - ✓ Engineers at Ball Aerospace are currently developing and testing the sequence needed to perform the spin-up
- The spacecraft will remain in SPS, while anomaly recovery efforts continue



### Plans



### **Battery Management**

- Continue to monitor performance improvement with MMKI gentle charging
- Continue to perform weekly battery health checks

### **Special Studies / Operational Improvements**

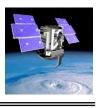
- Continue to look at alternate attitudes that will keep CPR warmer
  - ✓ Goal is to reduce the stability heater on time in eclipse
  - ✓ Thermal analysis is in progress
- Alternate "canned" COLA Maneuver location
- Update pre-loaded Exit Burn Blocks
  - ✓ Updated annually following the Inclination Maneuver Campaign
- Sun Sensor Calibrations
  - ✓ Tool has been completed / now running analyses.
- Magnetometer Calibrations
  - ✓ Tool is running / completing sanity checks on results.
- Update EIK Switch blocks to incorporate MMKI charging

### **Operational / Contingency Enhancements**

- MMSOC Data Distribution System (DDS) Implementation
- 3 Reaction Wheel Contingency Plans and Tables
- Contingency On-Orbit Handbook Updates
- Preparation for CPR EIK Switch Over



## Summary



### Daylight Only Operations (DO-Op) and science data collection continue

DO-Op requires continues to provide a very robust operating mode

### The Spacecraft and Cloud Profiling Radar continue to operate nominally

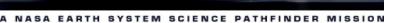
- There has been no loss of redundancy in the past year
- CPR experienced 1 HPA "Trip" in February (1st one since Nov '14)
- Battery health checks were suspended for seasonal loads and now continue on a weekly basis (1 orbit only)
- MMKI battery charging has shown proven results
- SASSI battery charging was discontinued in June 2017
- Magnetic Model was updated on the S/C in April 2017

### Reaction Wheel 1 Spin-Up / Anomaly Recovery is underway

- The anomaly did not trigger the A-Train Exit Criteria
- The S/C is in SPS and Science operations remain suspended
- Anticipate that spinning-up RWA-1 will return it to nominal operations

### The annual A-Train Inclination Maneuver Campaign has been completed

- 1st Inclination Decrease was on 22 February 2017
- 2<sup>nd</sup> Inclination Decrease is scheduled for 11 April 2017



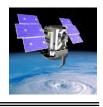
CLOUDSAT

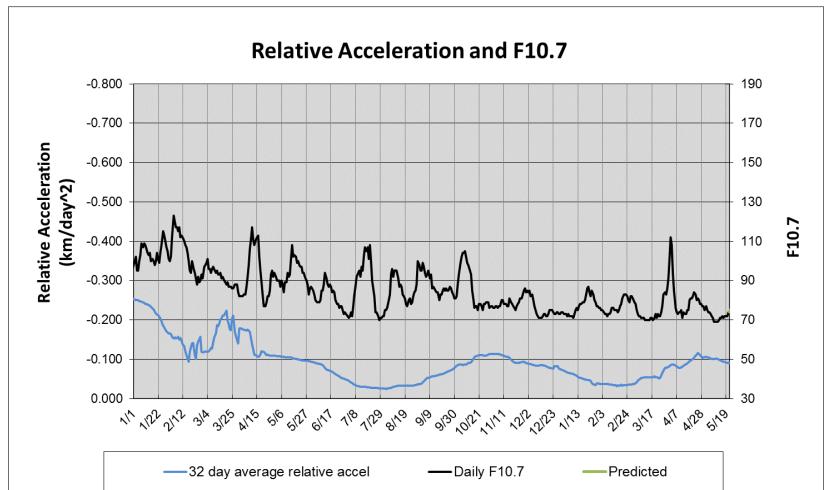


# Back-Up Charts



### Solar Data

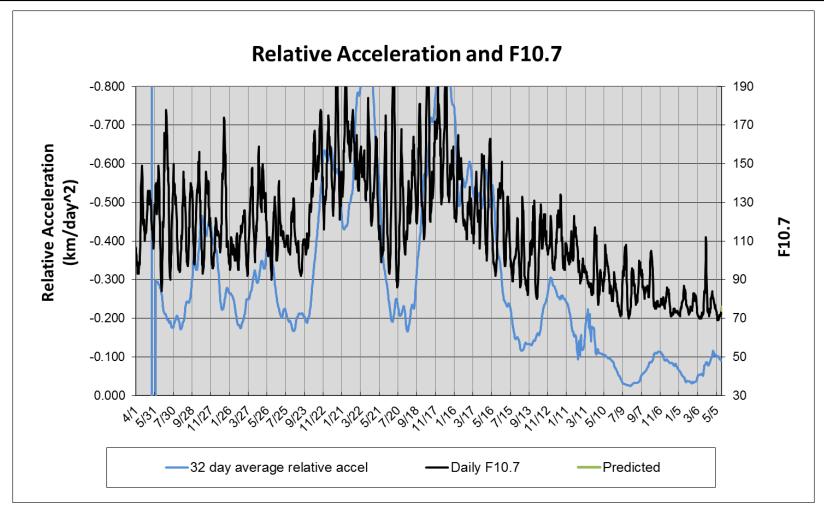






# Solar Data (Since 4/1/2012)







# Maneuver History



### • In 2015 CloudSat conducted 15 \*intentional\* maneuvers

- 8 orbit raises (for drag make-up)
- 4 orbit lowers (for ground track overlap maintenance)
- 1 risk mitigation (COLA) maneuver (also functioned as an orbit lower for ground track maintenance)
- 2 inclination decreases as part of the yearly inclination adjust campaign
- − 1 EMC firing

### In 2016 CloudSat conducted 11 maneuvers

- 5 orbit raises (for drag make-up)
- 4 orbit lowers (for ground track overlap maintenance)
- 2 inclination decreases as part of the yearly inclination adjust campaign
- In 2017 to date, CloudSat conducted 4 maneuvers
  - 1 orbit raise (for drag make-up)
  - 1 orbit lower (for ground track overlap maintenance)
  - 2 inclination decreases as part of the yearly inclination adjust campaign



# 



TCA Date / Time	Object Number	Object ID	First Identified On (Report Generation Time)		Highest Level of Action Taken
Multiple	32072	CBERS 1 DEB	01/02/2016 15:24	Various	No action taken
2/22/2016 12:25	30597	FENGYUN 1C DEB	02/18/2016 4:34	1.07E-05	No action taken
2/29/2016 16:15	41179	ORBCOMM FM 114	02/27/2016 19:02	9.24E-05	T1/T2 - Requested / received additional CARA Information
Multiple	35932	SWISSCUBE	04/03/2016 14:02	Various	No action taken
9/16/2016 01:42	34308	COSMOS 2251 DEB	09/12/2016 23:24	4.51E-05	T3 - Conducted preliminary burn planning



# Summary



- CloudSat continues to maintain its formation flying mission
  - Only one instance of ground track overlap loss since the last ops review (due to the attitude fault that resulted in a failed burn)
  - Since the last ops review, no risk mitigation maneuvers due to conjunctions were required
  - CloudSat successfully completed the 2017 Spring Inclination Adjust campaign
- CloudSat continues to work with the Air Force and NASA to monitor TanSat crossings